

What Is Claimed Is:

- Qb* ✓ 1. A decoding method for demodulating a received signal available in serial code concatenation in a code-division multiple access transmission system, a two-step coding being carried out at the transmitting end of the transmission system, a first step of the two-step coding including a Hadamard orthogonal multi-step inner code, a second step of the two-step coding including an outer error-correcting code of a predefined rate, the method comprising:
5 providing a soft-in/soft-out decoder in a receiver of the transmission system, a first decoder step of the soft-in/soft-out decoder including an inner decoder, a second decoder step of the soft-in/soft-out decoder including an outer decoder; and
10 processing soft values as reliability information at an output and an input of the soft-in/soft-out decoder, a soft output of the inner decoder being a soft input for the outer decoder, a channel reliability information output from a preceding demodulation
15 being an input for the inner decoder.
2. The method as recited in claim 1 wherein the inner code includes a 32-step modulation.
20 3. The method as recited in claim 1 wherein the inner code includes a 64-step modulation.
4. The method as recited in claim 1 wherein the outer code includes a convolution code.
25 5. The method as recited in claim 1 wherein the outer code includes a block code.
6. The method as recited in claim 1 wherein the reliability information includes L-values.
30 7. The method as recited in claim 1 wherein a soft input of the inner decoder includes a-priori information for systematic bits of Walsh functions of the inner code, the a-

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priori information being useable by the inner decoder for decoding the inner code.

8. The method as recited in claim 7 wherein the inner decoder includes a maximum a-posteriori decoder.

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9. The method as recited in claim 1 wherein to enhance reliability of decisions of the inner decoder, a soft output of the outer decoder is fed back as a soft input to the inner decoder as a-priori information for systematic bits of Walsh functions of the inner code.

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SJ The method as recited in claim 7 wherein the inner decoder includes a maximum a-posteriori decoder and wherein the a-priori information is made available to the inner decoder as reliability values in an a-priori vector $L(u)$ so that the inner decoder provides L-values for estimated symbols of an inner decoder soft value output vector $L(\hat{u})$, an amount $|L(\hat{u}_k)|$ of the L-values indicating a reliability of a respective decision and an operational sign of the $L(\hat{u}_k)$ representing a hard decision.

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11. The method as recited in claim 9 wherein the inner decoder includes a maximum a-posteriori decoder and wherein the a-priori information is made available to the inner decoder as reliability values in an a-priori vector $L(u)$ so that the inner decoder provides L-values for estimated symbols of an inner decoder soft value output vector $L(\hat{u})$, an amount $|L(\hat{u}_k)|$ of the L-values indicating a reliability of a respective decision and an operational sign of the $L(\hat{u}_k)$ representing a hard decision.

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12. The method as recited in claim 1 wherein the receiver includes a coherent receiver structure, wherein a soft input of the inner decoder includes a-priori information for systematic bits of Walsh functions of the inner code and wherein the inner decoder includes a maximum a-posteriori decoder, the maximum a-posteriori decoder calculating, starting from an input vector $L_C \cdot y$ having a specific reliability L_C and from an a-priori information vector $L(u)$, as a decoder result, a weighted decision including reliability L-values for estimated symbols, the L-values including an extrinsic term $L_e(\hat{u}_k)$.

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13. The method as recited in claim 1 wherein the receiver includes a coherent receiver structure, wherein a soft input of the inner decoder includes a-priori information for systematic bits of Walsh functions of the inner code, and wherein the inner code includes a Hadamard code, the Hadamard code being decoded by:

- 5 adding an a-priori information vector $L(u)$ for systematic bits of a Walsh function of the Hadamard code to an input vector $L_C \cdot y$ from a channel;
- 10 performing a fast Hadamard transformation so as to provide a fast Hadamard transform resultant vector w ;

15 then generating exponential functions with $\frac{1}{2} \cdot w_j$ as an argument, w_j being a respective element of the vector w ; and

20 adding, dividing and expressing logarithmically elements of a result vector z for each symbol \hat{u}_k to be decoded according to the equation:

$$\frac{\sum_{\substack{j, u_k = +1 \\ j=1}}^{N-1} z_j}{\sum_{\substack{j, u_k = -1 \\ j=1}}^{N-1} z_j} = \ln \frac{\sum_{\substack{j, u_k = +1 \\ j=1}}^{N-1} \exp(\frac{1}{2} w_j)}{\sum_{\substack{j, u_k = -1 \\ j=1}}^{N-1} \exp(\frac{1}{2} w_j)} = \ln \left(\sum_{\substack{j, u_k = +1 \\ j=1}}^{N-1} \exp(\frac{1}{2} w_j) \right) - \ln \left(\sum_{\substack{j, u_k = -1 \\ j=1}}^{N-1} \exp(\frac{1}{2} w_j) \right)$$

25 z_j being a respective element of the resultant vector z , j being a respective vector element index, N being a size of the Walsh functions of the inner code.

20 14. The method as recited in claim 1 wherein a result of the inner decoder for a bit \hat{u}_k includes a-priori information $L(u_k)$ about a bit to be decoded, channel information $L_C \cdot y_{sys(k)}$ about the bit to be decoded, and extrinsic information $L_e(\hat{u}_k)$, channel information and a-priori information on all other bits of a demodulator output vector y or of a transmitted Walsh function of the inner code being included in the extrinsic information $L_e(\hat{u}_k)$.

25 15. The method as recited in claim 1 wherein the receiver includes an incoherent receiver structure and wherein the inner decoder includes a maximum a-posteriori decoder, the maximum a-posteriori decoder calculating, starting from a square-law-

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combining fast Hadamard transform resultant decision vector w and from an a-priori vector L(u), as a decoder result, a weighted decision including the L-values for estimated symbols, the L-values including an extrinsic term $L_e(\hat{u}_k)$.

5 16. The method as recited in claim 1 wherein the receiver includes an incoherent receiver and wherein the outer decoder includes a maximum a-posteriori decoder, the soft output of the inner decoder including a-priori information for systematic bits of Walsh functions of the inner code useable for decoding of the inner code.

10 *S. H.* A decoding device for demodulating a received signal available in serial code concatenation in a code-division multiple access transmission system, a two-step coding being carried out at the transmitting end of the transmission system, a first step of the two-step coding including a Hadamard orthogonal multi-step inner code, a second step of the two-step coding including an outer error-correcting code of a predefined rate, the device comprising:

15 a soft-in/soft-out decoder disposed in a receiver of the transmission system, a first decoder step of the soft-in/soft-out decoder including an inner decoder, a second decoder step of the soft-in/soft-out decoder including an outer decoder, soft values being processed as reliability information at an output and an input of the soft-in/soft-out decoder, a soft output of the inner decoder being a soft input for the outer decoder, a channel reliability information output from a preceding demodulation being an input for the inner decoder.

20 18. The device as recited in claim 17 wherein the inner code includes a 32-step modulation.

25 19. The device as recited in claim 17 wherein the inner code includes a 64-step modulation.

30 20. The device as recited in claim 17 wherein the outer code includes a convolution code.

21. The device as recited in claim 17 wherein the outer code includes a block code.

22. The device as recited in claim 17 wherein the reliability information includes L-values.

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23. The device as recited in claim 17 wherein to enhance reliability of decisions of the inner decoder, a soft output of the outer decoder is fed back as a soft input to the inner decoder as a-priori information for systematic bits of Walsh functions of the inner code.

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24. The device as recited in claim 17 further comprising a RAKE receiver disposed upstream from the inner decoder, an output of the RAKE receiver including the channel reliability information output from the preceding demodulation.

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